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A new species of *Adenomera* (Anura, Leptodactylidae) from the *Araucaria* forest of Rio Grande do Sul (Brazil), with comments on the systematic status of southern populations of the genus

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We describe a new species of *Adenomera* from Rio Grande do Sul, southern Brazil. This new species inhabits the spiny understory of southern *Araucaria* forests, and can be most easily distinguished from other *Adenomera* by its small body size, unexpanded toe tips and distinctive advertisement call. Calls are analyzed, described, and compared to advertisement calls of other *Adenomera* of southern Brazil, and the systematic status of these populations is discussed.

INTRODUCTION

Extensive morphological variation both within and among populations of species of the leptodactylid genus *Adenomera* have traditionally rendered this a taxonomically difficult group. The potential use of advertisement call data as a means of resolving this group's systematics had already been suggested by HEYER (1984) and is being effectively used in resolving species identity in member species distributed throughout the Amazon Basin (ANGULO & ICOCHEA, in press; ANGULO et al., in press). Two species, *Adenomera marmorata* Steindachner, 1867 and *A. hokermanni* (Heyer, 1973), have been reported to occur in sympatry in southeastern Brazil (HEYER, 1973). Although these two nominal species have long been

suspected to be composites of two or more species (HEYER, 1977, 1984), it has not been until recently that enough acoustic data from different localities were collected to determine species identities within the group.

KWET (1998) reported the southernmost record for the genus in the Brazilian state of Rio Grande do Sul. This population, which was termed *Adenomera* cf. *marmorata*, has distinct advertisement calls compared with those from populations in the states of São Paulo, Rio de Janeiro and Santa Catarina. Comparison of specimens from Rio Grande do Sul with specimens from other localities in southeastern Brazil, including type material of the nominal species and their synonyms, revealed that there are also morphological differences associated to this different call. Based on this evidence, we conclude that the Rio Grande do Sul population comprises a new species of *Adenomera* and proceed to describe it herein.

MATERIALS AND METHODS

Individuals of the new species were collected in Rio Grande do Sul, at Serra Geral between 600 and 1000 m altitude, and later deposited in the Museu de Ciências e Tecnologia da PUCRS (MCP, Porto Alegre, Brazil). Specimens examined for comparisons are deposited in the Museu de Ciências e Tecnologia da PUCRS (MCP, Porto Alegre, Brazil), Naturhistorisches Museum Wien (NHW, Wien, Austria), Staatliches Museum für Naturkunde Stuttgart (SMNS, Stuttgart, Germany), National Museum of Natural History (USNM, Washington, D.C., USA), Museum für Naturkunde Berlin (ZMB, Berlin, Germany), Zoologisches Museum Hamburg (ZMH, Hamburg, Germany) and Zoologische Staatssammlung München (ZSM, München, Germany). Our specimens were fixed in 6 % formalin and preserved in 70 % ethyl alcohol. All measurements were made with digital calipers. The following measurements were made to the nearest 0.1 mm: snout-vent length (SVL), head length, defined as the diagonal distance from the tip of the snout to the right angle of the jaw (HL), head width, defined as the distance between the angles of the jaw (HW), horizontal eye diameter (ED); horizontal tympanum diameter (TD), eye-nostril distance (END); interorbital distance (IOD); internarial distance (IND), thigh length (THL); tibia length (TL), foot length (FL).

Field work took place from 1995 to 1999 (in each year from about October to March), at the Centro de Pesquisas e Conservação da Natureza Pró-Mata (CPCN) (29°30'S, 50°10'W), municipality of São Francisco de Paula, state of Rio Grande do Sul, Brazil. Acoustic signals were recorded using a Sony WM-D6C tape recorder, a Sennheiser microphone system K6 with ME66 module, and metal tapes Sony Metal XR-90. Advertisement calls of four males of the new species were recorded at CPCN Pró-Mata: (a) on 8 November 1995, 23 30 h, 19°C air temperature, (b) on 20 December 1995, 14 00 h, 26°C air temperature, (c, d) on 1 November 1996, 3 00 h, 16°C air temperature. These calls are unvouchered. Acoustic analysis was performed using a Macintosh based digital signal analysis software, Signalyze 3.12 (KELLER, 1994), at a sampling rate of 44.1 kHz and 16 bit precision. Temporal and spectral signal figures were produced using a combination of Signalyze 3.12, DADiSP, a PC-based sound analysis software, and Corel Draw. Measurements of six acoustic parameters were taken: call length, call rate, call rise time (time from beginning of call to peak amplitude), dominant frequency, other frequencies with perceptible energy and frequency modulation (measured as

the difference between final frequency and initial frequency). Temporal parameters were measured in milliseconds (ms) and spectral parameters in Hertz (Hz). Dominant frequency measurements were taken at the peak amplitude of each call.

Results

Adenomera araucaria sp. nov.
(fig. 1-2)

Holotype. MCP 2421, adult male, collected at the Centro de Pesquisas e Conservação da Natureza Pró-Mata (CPCN) (about 950 m a.s.l.), 29°30'S, 50°10'W, municipality of São Francisco de Paula, Rio Grande do Sul, Brazil, on 20 December 1996, by Axel Kwet and Marcos Di-Bernardo.

Paratypes. Nine specimens collected at the type locality by Axel Kwet and Marcos Di-Bernardo (MCP 1794, female, 19 December 1995, MCP 1849, subadult, 9 February 1996; MCP 3208, male, 19 March 1997; MCP 3209, subadult, 23 November 1997; MCP 3463, male, 20 December 1996; MCP 3672-73, males, 24 November 1998, MCP 3676, male, 11 January 1999, MCP 3677, female, 4 January 1999); two specimens collected near Encruzilhada das Antas, municipality of Bom Jesus, Rio Grande do Sul, by Axel Kwet and Marcos Di-Bernardo (MCP 3345-46, males, 4 January 1998).

Diagnosis. – A small sized *Adenomera* (maximum SVL 18.8 mm in males, 19.9 mm in females; tab. 1) with toe tips rounded or slightly swollen, not disked (stage B after Heyer, 1973). *Adenomera araucaria* differs from all other known species in the genus by its advertisement call. Morphologically, it is most similar to *Adenomera marmorata*, being distinguished from this species by: (1) toe tips not flattened, (2) white tubercles on tarsus and on sole of foot less developed, (3) shorter limbs; (4) snout more acuminate in dorsal and lateral view; and (5) ventral surface of thigh smooth, whitish, only sparsely dotted with gray (partly granular and dark mottled, often forming a net-like pattern in *A. marmorata*). Whereas the new species differs from northern populations of *A. marmorata* also by a smaller size (maximum SVL near the type locality about 24 mm in males and 25 mm in females, Heyer, 1973), specimens from southern populations of *A. marmorata* (which may be a distinct species) are equally sized (maximum SVL of *A. marmorata* at the type locality of *Leptodactylus nanus* Müller, 1922: 19.3 mm in males, 20 mm in females, tab. 1). *Leptodactylus trivittatus* Lutz, 1926, is considered synonymous with *A. marmorata*, having toe tips distinctly expanded.

Adenomera araucaria differs from *Adenomera bokermanni* (following the description of Heyer, 1973, but see discussion) by: (1) its smaller size (maximum SVL of *A. bokermanni*: 25.1 mm in males, 27.6 mm in females); (2) absence of perceptible white tubercles on tibia; and (3) distinct dorsal pattern, usually with longitudinal arranged dark marks and light dorsolateral and mid-dorsal stripes (dorsum commonly uniform or with indistinct marks in *A. bokermanni*). The new species is distinguished from all other known species of the genus, i.e., *Adenomera andreae* (Müller, 1923), *Adenomera diptyx* (Boettger, 1885), *Adenomera hylaedactyla* (Cope, 1868), *Adenomera lutzi* Heyer, 1975 and *Adenomera martinezi* (Bokermann, 1956) by its smaller body size. Further, it differs from nominal *A. andreae* and *A. lutzi* by non expanded toe tips, from *A. diptyx* and *A. hylaedactyla* by less rugose skin texture and from *A.*

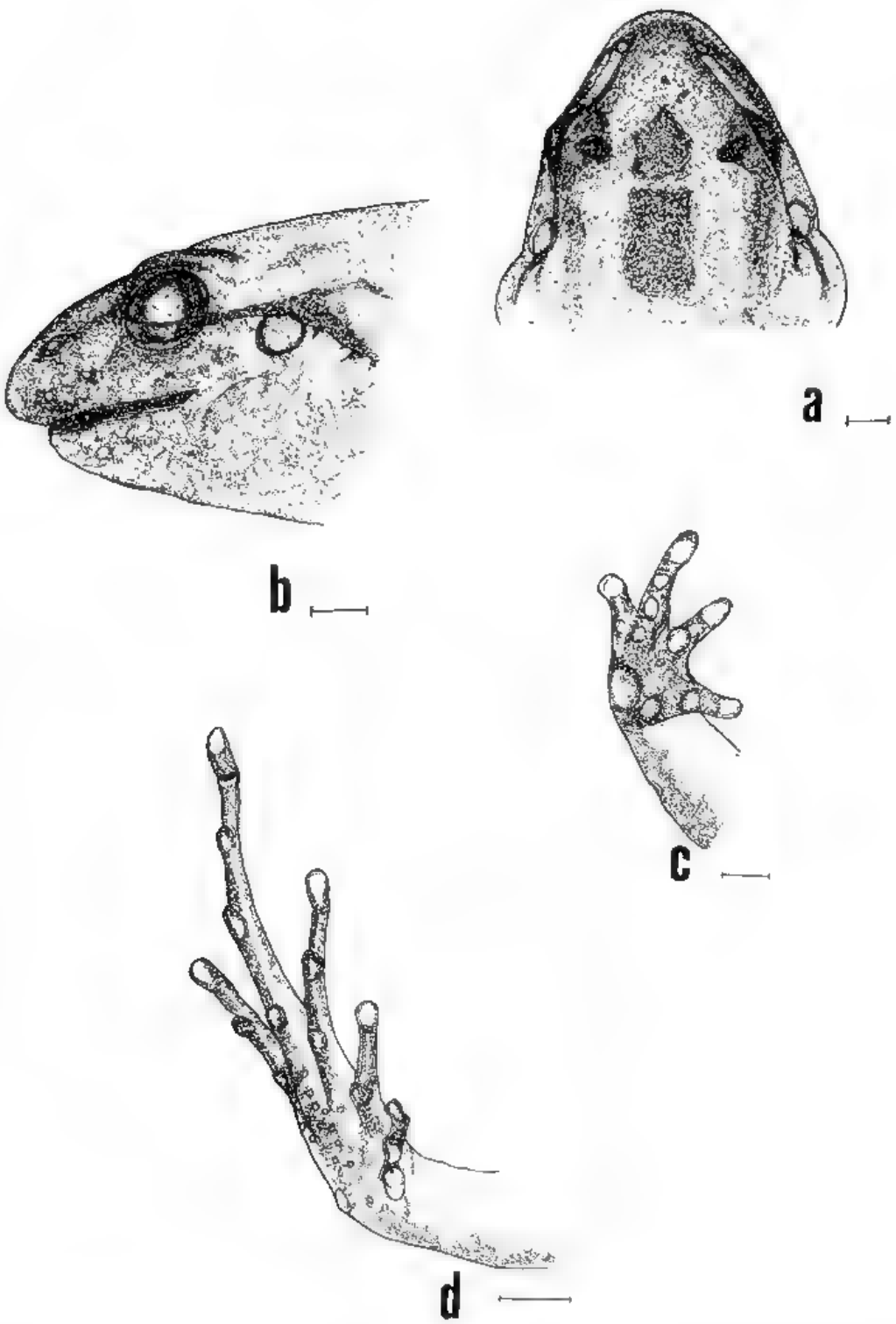

Fig 1 *Adenomera araucaria* sp nov , holotype, male, MCP 2421 (a) Lateral and (b) dorsal views of head; ventral views of (c) right hand and (d) right foot. Scale bar: 1mm

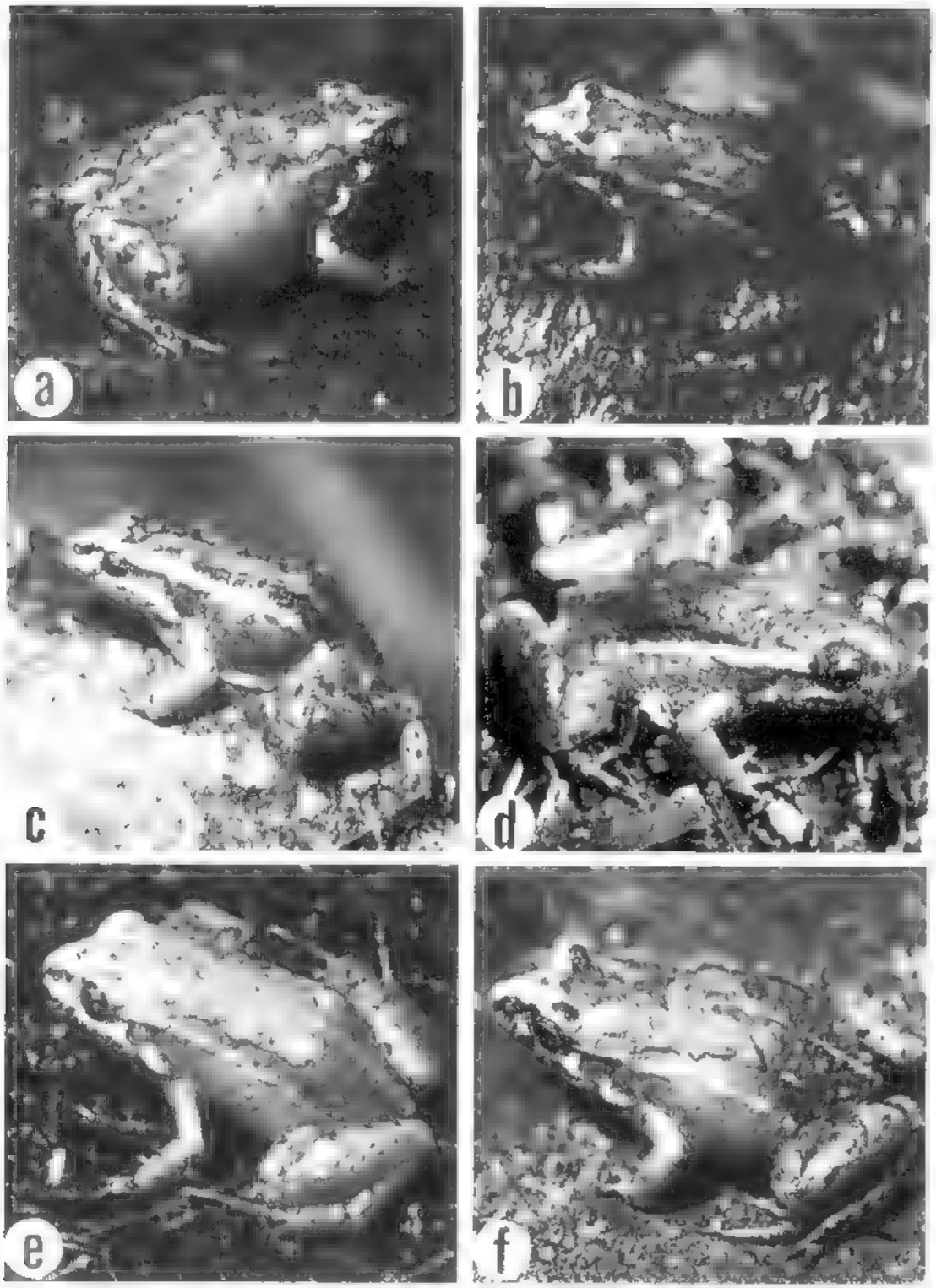

Fig 2 — *Adenomera araucaria*, type specimens in life showing intraspecific variation (a) MCP 2421 holotype, male; (b) MCP 1794, paratype, female (c) MCP 3346, paratype, male, (d) MCP 3208 paratype, male; (e) MCP 3676, paratype, male; (f) MCP 3463, paratype, male.

Table 1 – Morphometric characters for *Adenomera araucaria* from Serra Geral, Rio Grande do Sul, *Adenomera* cf. *araucaria* from Morro do Baú, Santa Catarina, and *Adenomera* cf. *marmorata* from Corupá, Santa Catarina (type locality of *Leptodactylus nanus*). *n*, sample size; *s*, standard deviation

	Adenomera araucaria Serra Geral, RS						*Adenomera* cf. *araucaria* Morro do Baú, Ilhota, SC				*Adenomera* cf. *marmorata* Corupá, SC					
	Males (*n* = 8)			Females (*n* = 3)			Male (*n* = 1)	Females (*n* = 5)			Males (*n* = 5)			Females (*n* = 7)		
	Range	Mean	*s*	Range	Mean	*s*		Range	Mean	*s*	Range	Mean	*s*	Range	Mean	*s*
Snout-vent length	17.1-18.8	18.4	0.59	19.3-19.9	19.6	0.31	17.9	18.6-20.0	19.2	0.52	17.1-19.3	18.4	0.92	17.3-20.0	18.8	0.90
Head length	5.9-6.5	6.2	0.20	5.7-6.9	6.2	0.61	5.7	5.8-6.8	6.4	0.44	5.5-6.2	5.9	0.26	5.9-6.3	6.0	0.14
Head width	5.5-6.7	6.0	0.37	5.9-6.0	6.0	0.06	5.6	5.6-6.5	6.0	0.41	5.4-6.1	5.4	0.28	5.7-6.4	6.1	0.28
Eye diameter	1.7-1.9	1.8	0.07	2.0-2.0	2.0	0	1.9	1.9-2.1	2.0	0.08	1.9-2.0	1.9	0.05	1.8-2.0	1.9	0.10
Tympanum diameter	1.1-1.3	1.2	0.07	1.3-1.3	1.3	0	1.1	1.1-1.3	1.2	0.08	1.0-1.2	1.0	0.08	0.9-1.4	1.1	0.17
Eye-nostril distance	1.4-1.7	1.6	0.09	1.4-1.7	1.6	0.15	1.6	1.5-1.9	1.7	0.18	1.4-1.7	1.4	0.11	1.6-1.8	1.7	0.08
Interorbital distance	3.4-3.9	3.6	0.20	3.4-3.7	3.5	0.17	3.4	3.3-3.7	3.5	0.16	3.2-3.7	3.2	0.23	3.2-3.8	3.5	0.23
Internarial distance	1.8-2.2	2.0	0.14	1.9-2.0	1.9	0.06	2.0	1.9-2.0	2.0	0.05	2.0-2.3	2.0	0.13	1.8-2.2	2.0	0.13
Femur length	7.3-8.2	7.8	0.35	7.8-8.1	8.0	0.15	8.4	8.2-8.9	8.5	0.26	7.5-8.8	7.5	0.50	8.2-9.6	8.7	0.51
Tibia length	7.6-8.3	7.9	0.27	8.0-8.8	8.4	0.40	8.7	8.5-9.1	8.8	0.25	7.6-8.9	7.6	0.48	8.2-9.7	8.9	0.53
Foot length	9.0-9.9	9.4	0.33	9.8-10.1	10.0	0.15	9.4	9.6-10.5	10.1	0.37	8.8-9.9	8.8	0.47	9.3-10.4	9.8	0.35

martinezi by dorsal pattern not consisting of four symmetrically arranged rows of longitudinal spots. *Adenomera araucaria* is currently known only from the southernmost extent of the Atlantic Forest Domain in southeastern Brazil.

Description of holotype Body small, robust, with short limbs (tab. 1). Head as long as broad, dorsal outline of snout subelliptical, slightly acuminate (fig. 1a); snout profile subacuminate (fig. 1b). Nostrils directed dorsolaterally, closer to tip of snout than to eye; internarial distance about one third of head width. Tympanum distinct, its diameter two thirds of eye diameter, supratympanic fold poorly developed, highlighted with black. Canthus rostralis indistinct, rounded. No cranial crests. Angle of jaw with white oval gland. Vocal sac single, internal. Paired, elongate vocal slits in males. Vomerine teeth in short transverse series, posterior to choanae and separated from each other by about the length of one tooth row. Arms and fingers relatively short. Finger lengths III > I = II > IV; finger tips rounded, not expanded, fingers without webbing or fringes (fig. 1c). Two large, ovoid metacarpal tubercles; size of outer metacarpal tubercle about two times inner metacarpal tubercle; prominent, rounded subarticular tubercles on fingers. Nuptial asperities absent. Hindlegs short, tibia a little longer than femur. Toe lengths IV > III > V > II > I; toe tips slightly swollen but not noticeably expanded nor flattened, toes without webbing or fringes (fig. 1d). Distinct, ovoid metatarsal tubercles and rounded subarticular tubercles; inner metatarsal tubercle slightly larger than outer metatarsal tubercle. Distinct inner tarsal fold. Sole of foot and lower surface of tarsus with small, but relatively distinct tubercles. Upper shank surface smooth, without perceptible white tubercles. Dorsal texture smooth, except some tubercles around vent (on posterior region of thighs and on sacral region) and, dorsolaterally, two longitudinal glandular folds. A distinct lateral fold partly separated into small glandular segments extending from eye, over tympanum and shoulder, to inguinal region. Above this fold a second, less distinct dorsal fold from shoulder to sacral region. Ventral surface smooth.

Color in life. – Dorsal coloration orange-brown, with a symmetrical pattern of dark marks (fig. 2a). A black, pentagonal interorbital spot followed by a larger rectangular blotch between shoulders (fig. 1a) and another spot on anterior part of dorsum. A black stripe on each dorsal glandular fold joined on middorsum by a black bar, and a light stripe on each lateral fold. On posterior half of body, a light mid-dorsal stripe. A black line from nostril to anterior margin of eye; another line from posterior margin of eye, over tympanum and a white gland on angle of jaw, to insertion of arm. Black, irregular cross-bars on hindlimbs and partly on arms. Belly white, immaculate, skin on throat and ventral surface of thigh very sparsely dotted with small melanophores.

Color in preservative In 70 % alcohol, dorsum brownish with the dorsal pattern of dark marks described above. Venter white, immaculate.

Measurements of holotype (in mm) SVL 18.1, HL 5.9, HW 5.9, ED 1.8, TD 1.2; END 1.6, IOD 3.5; IND 1.9; THL 7.3; TL 7.6; FL 9.3.

Variation. Females slightly larger than males (tab. 1). Dorsal outline of snout subelliptical or nearly acuminate in males but more rounded in females. In all specimens, inner metacarpal tubercle smaller than outer metacarpal tubercle, in size varying between one half and two thirds. Dorsal coloration very variable, consisting of various shades of light or dark brown, orange-brown, tan or gray, with a usually inconspicuous pattern of longitudinally arranged, irregular, dark marks (fig. 2, see color photos in Kwet & Di-Bernardo, 1999). Variable,

black, triangular or hourglass-shaped interorbital spot from between upper eyelids to region between shoulders. Light middorsal stripe usually extending from above vent to middle of body not reaching head; this stripe very weak in one of the 12 type specimens (MCP 3676). Dorsolaterally, most specimens with two black longitudinal lines and below with two finer, light stripes, but in two specimens (MCP 3208, 3346), these stripes expanded into broad, white lateral lines. Two specimens (MCP 3673, 3677) with dark dorsal coloration and pattern hardly visible. Ventral surface of body usually white, finely dotted with gray on throat and posterior part of thighs, but one specimen (MCP 3209) very dark ventrally, with a lot of melanophores on lower thighs, throat and belly

Advertisement call — Acoustic parameter measurements of four specimens are listed in tab. 2; fig. 3 depicts oscillogram, spectrum, and sonogram images of the call. The call length of the new species ranges from 85.5 to 139.5 ms in duration and call rate is relatively slow (26.2 to 44.8 calls/min). Call onset is gradual and call rise time varies from 35.1 to 81.0 ms, constituting approximately 26.8 to 66.6 % of the total call duration. The call does not possess perceptible pulses, although it does show some amplitude modulation that can take the form of 5-11 severe amplitude modulations on the amplitude envelope. The call is a frequency-modulated signal, with an upward frequency sweep where the end of each call has a higher frequency than the respective beginning of the call. This frequency sweep is audible to the human ear and varies from 775.3 to 1808.8 Hz. The fundamental frequency or first harmonic lies between 1722 and 3359 Hz and the main carrier frequency oscillates between 4625 and 5403 Hz, comprising the second harmonic band. Other frequency components which have some energy lie approximately at 5943-8613 Hz and 8354-10938 Hz. A much higher harmonic band also presents perceptible energy, greater than all other aforementioned frequencies, except for the carrier, between 13716 and 15231 Hz. However, the energy peaks of any of these frequencies are substantially lower than the main carrier, making the call almost a pure tone (see spectrum on fig. 3; other frequencies are not depicted as their energy levels fall below the cutoff point of -30 dB). The number of frequencies detected at any one time in calls varies from three to six, although this may vary with recording conditions.

Natural history — The new species inhabits subtropical rainforest of northeastern Rio Grande do Sul and southern Santa Catarina, from about 300 to 1100 m altitude. It was very abundant in secondary forests and *Araucaria* stands on the eastern Planalto of Rio Grande do Sul. Most specimens were found near trunks of the Paraná pine, *Araucaria angustifolia*, where they may find protection against potential predators by hiding among the spiny leaves of this conifer. *Adenomera araucaria* is a predominantly diurnal species. During the breeding time from October to late January, males usually called from early afternoon to midnight. No specimens were heard at late night or at dawn. Calling activity increased after showers. Males were calling on the ground, mostly hidden between roots, stones and fallen branches. Neither eggs nor tadpoles were found but terrestrial reproduction in foam nests with non-feeding larvae is assumed (mode 22 after DUELLMAN & TRUEB, 1985), as described for most other members of the group (e.g., HEYER et al., 1990), because *Adenomera araucaria* was never observed near streams or standing water. At Pro-Mata, the new species was found living in sympatry with *Eleutherodactylus* cf. *guenthert*.

Distribution — *Adenomera araucaria* occurs in the southern region of the Serra Geral, southern Brazil. At present, it is known from several municipalities in northeastern Rio

Grande do Sul, i e., Bom Jesus, Cambará do Sul, Canela, Gramado, São Francisco de Paula and São José dos Ausentes. The municipality of São Francisco de Paula marks the southernmost distribution limit of new species, the genus and the Atlantic Rainforest Domain. Calling specimens were also heard in southern Santa Catarina, municipality of Timbé do Sul (on 4 January 1998). It is not known where the northern and western distribution limits of *A. araucaria* lie, but the species may be restricted to a small area of the southern Serra Geral. Populations from northern Santa Catarina are slightly different and probably belong to another species (see discussion) Specimens from Misiones, Argentina, have different calls (Diego Baldo, personal communication) and presumably represent the recently revalidated *Adenomera diptyx* (Boettger, 1885) (De la Riva, 1996).

Etymology The new species is named after the Paraná pine, *Araucaria angustifolia*, in allusion to the preferred microhabitat at CPCN Pró-Mata and the difficulty of finding specimens in the spiny understory of the *Araucaria* forest. The name is used as an invariable noun in apposition.

Discussion

Differences in morphological features have traditionally been considered good evidence for allocation of specific status. With the advent of technology, the acoustic realm has undergone a boost, as it is now possible to visualize and analyze signals digitally Advertisement calls have become as important as morphology in species determination in anurans, at times being the major discriminator between one or another population (e.g., Heyer et al., 1996). Because advertisement calls are important in species recognition, work as premating isolating barriers among sympatric species (Duellman & Pyles, 1983) and tend to be rather stereotyped, workers use them for species identification in the field.

Heyer (1974) studied the relationships of the *marmoratus* species group within the family Leptodactylidae and revalidated the genus *Adenomera*. Heyer (1977) also suggested that *Adenomera marmorata* may be a composite species, although the evidence was not as clear as for *Adenomera bokermanni* He found a broad overlap in morphological characters between different populations from southeastern Brazil and stated that advertisement call data are needed for resolving the systematics of this group (Heyer, 1984). Our comparison of calls of *Adenomera* from Rio Grande do Sul (tab. 2, fig. 3) with those from other localities in southeastern Brazil demonstrate noticeable differences. Barrio (1965) described the call of *A marmorata* from Paranapiacaba, state of São Paulo At a temperature of 20°C, he described a call length of 100 ms, issued at a call repetition rate of 75 calls/min, a fundamental frequency of 2200-3200 Hz and a dominant frequency of 5200 6000 Hz. Straughan & Heyer (1976) described the call of *A marmorata* from Tijuca, state of Rio de Janeiro (figured in Heyer, 1973). At 22°C, they reported call length to be of 100 ms and a call repetition rate of 94 calls/min, while the dominant frequency oscillated between 4500-5600 Hz, and an apparent broad fundamental below 1000 Hz, amplitude modulation apparent throughout call Heyer et al (1990) also reported the call of *A marmorata* from Boracéia, São Paulo At a temperature of 18°C, call lengths were found to vary between 40 and 70 ms in duration, issued at a rate of 0 8 to 1.4 calls/s (approximately 48-84 calls/min), with a main carrier frequency (which is also the fundamental frequency) of 4500 to 5400 Hz Call onset was abrupt and intensity was

Table 2. Acoustic parameters for four males (a-d) of *Adenomera araucaria*. Numbers of first line are means ± standard deviations, numbers in brackets are ranges.

Recording	(a) 8 Nov. 1995	(b) 20 Dec 1995	(c) 1 Nov. 1996	(d) 1 Nov 1996
Number of calls	4	20	11	8
Temperature (°C)	19	26	16	16
Call length (ms)	90.0 ± 4.3 (85.5-95.7)	127.6 ± 3.1 (123.5-137.3)	129.3 ± 3.4 (125 6-136.6)	134.3 ± 2.7 (130 6-139 5)
Call rate (calls/min)	34.6	44.8	26.2	27.4
Call rise time (ms)	56.3 ± 6.0 (47 3-60.2)	57.5 ± 16.2 (41 2-81.0)	46 9 ± 11.1 (35.1-64 8)	39.1 ± 4.7 (35.6-50.4)
Dominant frequency (Hz)	5318 ± 68 (5263-5403)	5000 ± 94 (4885-5144)	4672 ± 43 (4625-4745)	4650 ± 37 (4625-4705)
Other frequencies with perceptible energy (Hz)	–	14847 ± 247 (14593-15231)	13875	13819 ± 86 (13716-13995)
Frequency modulation (Hz)	1076 7 ± 258 4 (775.3-1292.0)	1438 4 ± 218.4 (1033 6-1808.8)	822.2 ± 20 0 (861.3-947.5)	818.3 ± 46 0 (775.2-861.3)

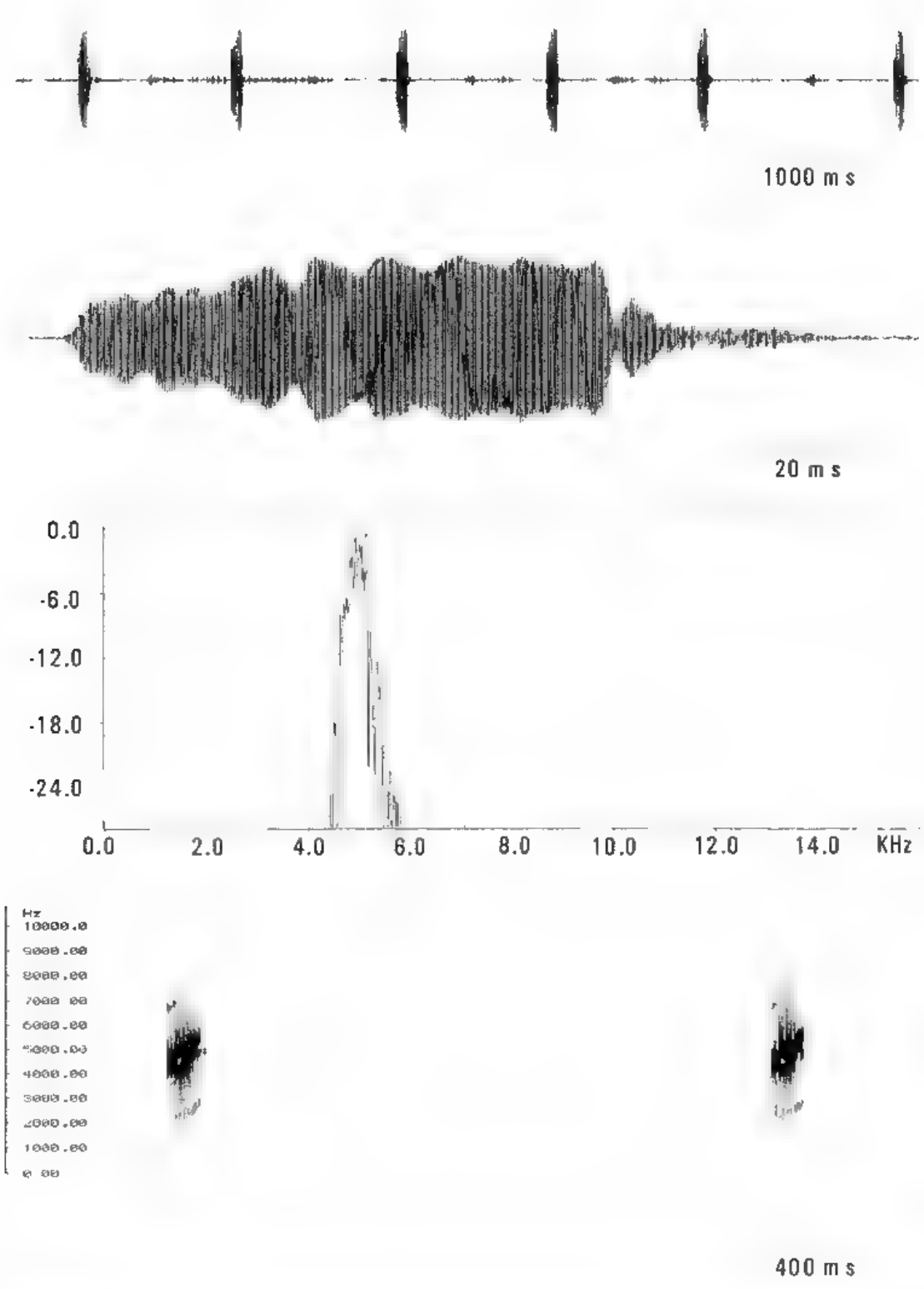

Fig 3 Oscillogram of six calls, waveform at higher resolution, power spectrum and audiospectrogram of the advertisement call of *Adenomera araucaria* from Pro-Mata Rio Grande do Sul, recorded on 20 December 1995, 14 00 h, air temperature 26°C; no voucher specimen

maintained for most of the beginning of the call, declining towards end. There was upward frequency modulation within the call, and no harmonics were reported.

In addition to these reported calls, W. R. Heyer kindly made available to us recordings of *Adenomera* from an area geographically close to Rio Grande do Sul, Pirabeiraba, in Santa Catarina, and Serra da Bocaina, São Paulo (see tab. 3). We have identified two distinct advertisement calls from Pirabeiraba and have analyzed recordings from two calling males ($n = 2$) for each of the two call types (there is one voucher specimen for call type II and two for call type I but calls from one of the Pirabeiraba I call type vouchers were not used in analysis due to the very poor signal to noise ratio). For the population of Serra da Bocaina, we have analyzed recordings from three calling males ($n = 3$). For comparative purposes, calls from Serra da Bocaina have been tentatively assigned to *Adenomera bokermanni* because: (1) the frogs were heard calling and were collected in an open formation environment, which is understood to be the preferred habitat of *A. bokermanni* (HEYER, 1984), and (2) the single voucher has slender, unexpanded toe tips (characteristic of *A. bokermanni*; HEYER, 1984) and besides a discontinuous mid-dorsal dark brown stripe running from shoulder to groin, the dorsal pattern is mostly uniform. However, nominal *A. bokermanni* has long been suspected to be a composite of more than one species (HEYER, 1977, 1984), and given that its taxonomy still remains unresolved we are conservative about allocating this population to *A. bokermanni* in a definitive way. On the other hand, the single vouchers for the two distinct call types from Pirabeiraba differ from each other as one has expanded toe tips (call type II) and a nearly rounded to rounded snout, whereas the other has slender, unexpanded toe tips (call type I) and a subelliptical to pointed snout, so we believe that there are at least three different taxa considering both localities. Unfortunately, because the number of call vouchers is limited, it is difficult to properly allocate identities to these populations, but it is important to compare the new species' call to those in geographic proximity and to note that there are more advertisement calls than available names.

With regards to reported calls, there is overlap in values of main carrier frequency for all three reported calls and the new species. There are, however, clear differences with each reported call. The new species has a much lower call rate than any of those reported in the literature, presenting no overlap with any of them, save the closeness of the Boraceia calls calling rate. There is overlap in call length with calls from Paranapiacaba and Tijuca, but calls from Boracéia are shorter than those of the new species. The Boracéia calls do not have severe amplitude modulations, which calls of the new species possess. The call from Rio de Janeiro has apparent intensity (amplitude) modulation (STRAUGHAN & HEYER, 1976), but it is difficult to tell in the case of the Paranapiacaba call as spectrogram information does not allow observation of amplitude patterns in detail. Additionally, although the number of harmonics detected will be a function of the closeness of the recording equipment to the animal and of the recording equipment per se, the new species consistently shows higher harmonics, extending to about 15 kHz.

In contrast with both call types from Pirabeiraba, calls of the new species are consistently longer. Call rate is also notably lower in the new species than that of Pirabeiraba call type I, although there is some overlap with Pirabeiraba call type II. Call rise time is generally longer in the new species than in the Pirabeiraba calls, although this parameter is subject to considerable variability. Main carrier frequency differs by about 1600-2000 Hz with Pirabei-

Table 3 – Acoustic parameters for two distinct call types of *Adenomera* from Purabeiraba, Santa Catarina (a-d; *Adenomera* cf. *marmorata*, call type I and II) and for *Adenomera* from Serra da Bocaina, São Paulo (e-g, *Adenomera* cf. *bokermanni*). Numbers of first line are means ± standard deviations, numbers in brackets are ranges. Question marks (?) indicate that frequency values observed may be a product of masking background noise rather than the acoustic signal being measured. *Adenomera* cf. *bokermanni* shows negative values or none at all for frequency modulation (Hz) as this modulation may be inverse (falling frequency with time rather than rising) or nonexistent.

Recording	(a) USNM 318237	(b) no voucher	(c) USNM 243740	(d) no voucher	(e) no voucher	(f) USNM 318183	(g) no voucher
Identification	*Adenomera*, call type I, Purabeiraba	*Adenomera*, call type I, Purabeiraba	*Adenomera*, call type II, Purabeiraba	*Adenomera*, call type II, Purabeiraba	*Adenomera*, Serra da Bocaina	*Adenomera*, Serra da Bocaina	*Adenomera*, Serra da Bocaina
Number of calls	10	10	10	3	10	10	10
Temperature (°C)	24.5	24.5	21.5	–	–	19-20	19-20
Call length (ms)	71.6 ± 3.7 (67.7-79.1)	88.2 ± 6.6 (80.1-98.0)	75.9 ± 3.5 (70.1-80.8)	75.9 ± 12.2 (61.9-83.9)	58.4 ± 2.3 (54.3-61.5)	52.6 ± 1.7 (51.2-55.9)	48.4 ± 4.2 (45.4-59.7)
Call rate (calls/min)	93.2	113.1	37.1	31.7	308.7	238.6	288.9
Call rise time (ms)	2.9 ± 3.6 (0.4-9.2)	7.3 ± 13.2 (0.9-43.9)	28.1 ± 25.4 (6.6-68.2)	11.9 ± 1.1 (10.6-12.7)	14.0 ± 2.2 (8.5-16.1)	16.3 ± 1.4 (13.5-18.6)	11.8 ± 2.9 (7.6-15.9)
Dominant frequency (Hz)	3038 ± 17 (3030-3070)	3034 ± 13 (3030-3070)	5343 ± 77 (5212-5443)	5285 ± 30 (5251-5311)	2284 ± 13 (2248-2288)	2213 ± 0 (2213-2213)	2327 ± 19 (2288-2367)
Other frequencies with perceptible energy (Hz)	–	–	3011 ± 189? – 10779 ± 189 (10486-10965)	7963 ± 185? – 10529 ± 61 (10462-10582)	4396 ± 155 (4177-4694) 6398 ± 87 (6273-6531)	4296 ± 691 (3808-4785)	–
Frequency modulation (Hz)	325.4 ± 134.7 (86.1-516.8)	620.2 ± 79.2 (516.8-775.2)		601.6 ± 0 (601.6-601.6)	(85.9-171.9)	(-86.1-200.4)	(0-257.8)

raba call type I and there is some overlap with call type II. Calls of the new species are audibly frequency-modulated, and although there is almost no overlap with Pirabeiraba call type I in frequency modulation, this is not obvious in the case of Pirabeiraba call type II. To the ear, Pirabeiraba call type II seems to be less frequency modulated than the new species' call, although measuring this modulation was not possible due to the excessive background noise and poor signal to noise ratio. In addition, the one voucher for Pirabeiraba call type II is rather small (SVL 17.1 mm), has rounded, expanded toe tips, and a nearly rounded to rounded snout, which could fit the new species. With regards to *Adenomera* cf. *bokermanni* calls from Serra da Bocaina, these are much shorter in length than those of the new species, and call rate is several orders of magnitude higher in *A.* cf. *bokermanni* than what it is in the new species. Call rise time is also much longer in the new species' call than in *A.* cf. *bokermanni*. The main carrier frequency differs by about 2500-3000 Hz between these taxa, and frequency modulation in *A.* cf. *bokermanni* is either nonexistent, negative or minimal, whereas the new species possesses considerable frequency modulation. Overall, and with the exception of Pirabeiraba call type II, the differences in call rate, call length, main carrier, amplitude modulation and higher harmonics support that this is a distinct call distinguished from any other reported in the literature for the southeastern Brazil region.

Although the morphological characteristics of *Adenomera araucaria* revealed intraspecific variation, especially in dorsal coloration, which could make discrimination from other species of the genus difficult, the combination of several features should in most cases allow identification, i.e., small body with short arms and hindlimbs, non-expanded toe tips, whitish ventral surface of thigh without granules, inconspicuous dorsal pattern of longitudinally arranged, dark marks and development of tubercles on tarsus and sole of foot. The new species is most similar to *Adenomera marmorata*, but our examination of the holotype (NHM 1946.3, fig. 4a), presumably from Rio de Janeiro (BOKERMANN, 1966), revealed notable differences, e.g., larger body proportions (SVL 21.6 mm, HL 7.7 mm, HW 7.4 mm, THL 9.2 mm, TL 9.6 mm) and intensively granulated lower parts of thigh.

On the other hand, only small morphological differences were found comparing the new species with small-sized *Adenomera* from populations in northern Santa Catarina that, at present, are allocated to *A. marmorata*. Specimens from Corupá and Pirabeiraba, both localities near the border of Paraná about 50 km from each other, differ from *A. araucaria* only in subtle characteristics. Besides the toe tips being a little more expanded and the ventral surface of thighs more granular and dark mottled, the dorsal pattern is more accentuated. Our comparison with the type material of *Leptodactylus nanus* (ZSM 661/1920/1-3, fig. 4b) described from Corupa (MÜLLER, 1922) confirmed that this is a species different from *Adenomera araucaria*. However, material collected at Morro do Baú, Ilhota, about 50-100 km southeast from Corupá, differ morphologically very slightly and only gradually from *A. araucaria* and, therefore, could be conspecific with this species. The most noticeable difference is the dorsal pattern, which consists of conspicuous blotches producing a symmetrical, dark brown marbling in five of eight specimens examined. Morro do Baú lies in the crystalline coastal range of the Serra do Mar in northeastern Santa Catarina, about 200-300 km distance from the Serra Geral in Rio Grande do Sul, where the new species occurs. Both mountain ranges are geologically different and separated by the southeastern Catarinean depression. Pending further studies, including analysis of advertisement calls from Morro do Bau, this population is identified as *Adenomera* cf. *araucaria*.

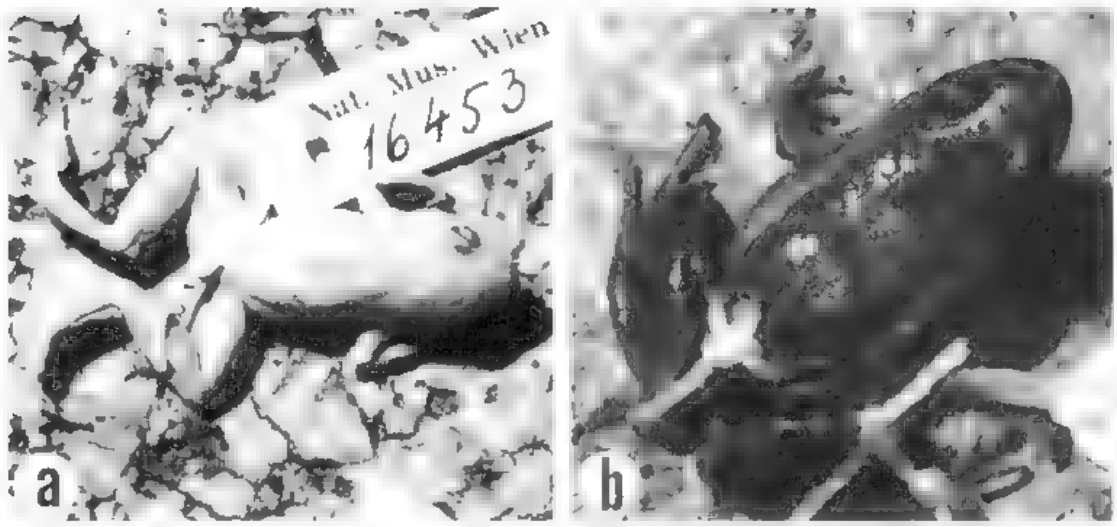

Fig. 4 – (a) *Adenomera marmorata*, holotype, NHM 16453, (b) *Leptodactylus nanus*, lectotype, ZSM 661.1920.3.

Based on combined evidence from bioacoustical and morphological data, the differences between the populations of *Adenomera* in Rio Grande do Sul and other populations in southeastern Brazil (with the exception of possible conspecific specimens from Morro do Bau and call type II from Pirabeiraba) justify the allocation of specific status to the southernmost contingent of the genus in Brazil.

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APPENDIX 1

ADDITIONAL SPECIMENS EXAMINED

Adenomera andreae (Muller, 1923). BRAZIL: AMAZONAS, Itacoatiara SMNS 8718 1-7, PARA, Peixeboi. lectotype ZSM 145 1911 4, paralectotypes ZSM 145.1911 1-3 PERU Rio Yuyapichis, Panguana: SMNS 7131.

Adenomera araucaria sp. nov. BRAZIL: RIO GRANDE DO SUL, São Francisco de Paula, CPCN Pró-Mata: SMNS 9023

Adenomera cf *araucaria* BRAZIL SANTA CATARINA, Ilhota, Morro do Baú: MCP 1345-52

Adenomera bokermanni (Heyer, 1973) - BRAZIL RIO DE JANEIRO, Niteroi ZSM 34 1947 BRAZIL: BAHIA, Ilhéus, Centro de Pesquisas do Cacau: USNM 336245-48.

Adenomera diptyx (Boettger, 1885) PARAGUAY: paralectotype ZMB 10595

Adenomera hylaedactyla (Cope, 1868) BOLIVIA BENI SMNS 9087 ECUADOR MORONA-SANTIAGO. SMNS 7751, NAPO: SMNS 7762 PERU Rio Yuyapichis, Panguana. SMNS 6384, 7132, 8853 SURINAM: Caboeri creek: SMNS 8222 1-3.

Adenomera marmorata Steindachner, 1867 BRAZIL RIO DE JANEIRO holotype NMW 16453, SÃO PAULO, Salesopolis, Boracéia USNM 209116-20, São Sebastião island ZSM 19 1952 1-3

Adenomera cf *marmorata* I (*Leptodactylus nanus* Muller, 1922) BRAZIL SANTA CATARINA, Pirabeiraba USNM 243737-39, 243741-42, Rio Novo, Colonia Hansa ZMH A 01737-44, A 01746-50, lectotype ZSM 661.1920 3, paralectotypes ZSM 661.1920 1-2

Adenomera cf *marmorata* II BRAZIL SANTA CATARINA, Florianopolis island MCP 1340

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